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Drilling Apparatus

Background of the invention

The present invention relates to a single pass drilling apparatus, a rock bolt, use of a drill bit and a method for single pass rock bolting according to the preambles of the independent claims within the areas of reinforcement, stabilization of excavations, road banks drilling, bench drilling, tube installation or case drilling.

The installation of rock bolts to reinforce excavations is usually carried out in two distinct steps. Usually, a hole is drilled and the drill steel and bit extracted before the bolt is inserted into the hole and tightened or grouted. Single pass rock bolting involves carrying out these two steps simultaneously, with the task of removing the drill steel to insert the bolt being eliminated. The advantages of single pass bolting include minimizing the time required for bolt installation, improving safety for drilling equipment operators, when comparing with manual or semi manual bolting, and enhancing prospects for full automation of the process. A further advantage is improved quality and precision of rock bolt installation, when comparing with manual or semi manual bolting. The diameter of the hole is critical for rock bolt performance in the case of friction, e.g. Split set, bolts. Still a further advantage with single pass bolting is that the hole cannot collapse when retracting the drill bit since the bolt is already in the hole. This leads to much better efficiency as the bolt is always installed; i.e. there will be no lost holes.

Prior attempts at single pass bolting have generally been targeted at innovative rock bolts, which also act as the drill steel, having a drill bit provided about an end thereof. Such apparatus are used via a rotational drilling method or a rotary/percussive drilling method and are generally unsuitable for hard ground conditions. Existing hard ground percussive rock bolts that do not reuse the drill bit suffer from cost problems. A wide variety of roof bolts exist and one particular form is tubular (e.g. split-sets, Swellex, etc.), having a central bore formed

lengthwise through the bolt. Drill bits adapted to be extracted through a casing have been complex and accordingly expensive. Cost competitiveness of drilling speed versus bit cost are complicated in prior single pass rock bolts due to the use of specialized rock bolts and the exclusive use of either complex retractable bits. It nevertheless remains the case, that the installation advantages of a self-drilling roof bolt outweigh those of the non-self-drilling type.

<u>Objects of the invention</u>

The drilling apparatus, the rock bolt, the use of the drill bit and the method of the present invention have as one object thereof to substantially overcome the above-mentioned problems associated with the prior art, or at least provide an alternative thereto.

Another object of the present invention is to provide a single pass drilling apparatus for roof bolts.

Still another object of the present invention is to provide a tubular expansible self-drilling roof bolt.

Still another object of the present invention is to provide a single pass drilling apparatus for roof bolts that is less costly to use than roof bolts of the kind described above and so to make their use in the mining industry more attractive.

Still another object of the present invention is to provide an optimal a single pass drilling apparatus for roof bolts that allows the use of simpler and smaller equipment as compared to today's mechanized systems.

Still another object of the present invention is to suggest the use of a drill bit in a single pass drilling apparatus for roof bolts that allows the reuse of the drill bit.

Throughout the specification, unless the context requires otherwise, the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusions of any other integer or group of integers.

Brief description of the drawings

The attached drawings show example embodiments of the invention of the foregoing kind. The particularity of those drawings and the associated description does not supersede the generality of the preceding broad description of the invention.

Figs. 1A – 1G schematically show a sequence of single pass roof bolting using an apparatus according to the present invention.

Fig. 1H shows a cross-section of the drilling apparatus in the hole similar to Fig. 1D.

Fig. 1K shows a cross-section of the drilling apparatus in the hole similar to Fig. 1E.

Fig. 1L shows an exploded view of the drilling apparatus according to the present invention.

Figs. 2A and 2B show a side view of the drilling apparatus according to Fig. 1C and an end view of the drill bit according to the present invention.

Figs. 3A and 3B show an alternative embodiment of a drilling apparatus for single pass bolting in similar views as Figs. 1H and 1K.

Figs. 4A and 4B show an alternative embodiment of a drilling apparatus for single pass bolting according to the present invention in similar views as in Figs. 1H and 1K.

Figs. 5A and 5B show an alternative embodiment of a drilling apparatus for single pass bolting according to the present invention in similar views as Figs. 1H and 1K.

Detailed description of the invention

Figs. 1A – 1G show a single pass drilling apparatus 10 according to the present invention. The single pass drilling apparatus 10 comprises several parts. An elongated drill steel 11 having a leading end 12 and a trailing end 13 with reference to a drilling direction F. The leading end 12 has a connection portion comprising a thread 15, a taper or a bayonet connection, not shown. A one-piece

drill bit 16 having rock machining means 17 and 18. The drill bit 16 is connectable to the drill steel via a connection portion comprising a thread 20, a taper or a bayonet connection, not shown. The single pass drilling apparatus 10 further comprises a rock bolt 21 adapted to at least partially enclose the drill steel 11. The greatest diametrical dimension of the drill bit is smaller than the smallest diameter of the rock bolt.

The basic idea of the single pass drilling apparatus 10 according to the present invention is to drill the hole with the bolt enclosing the drill steel, and then to retract the bit with no problem. There are no losses of bit parts.

The drill bit 16 can be designed as follows reference being had to Figs. 1K or 2A and 2B. The one-piece drill bit 16 has two integral parts, i.e. a pilot part 14, long enough to guide the entire apparatus 10 properly where the axis CL1 of the pilot part 14 coincides with the axis CL3 of the hole 22, and a reamer part 19. The center axis or middle line CL1 of the pilot part 14 substantially coincides with the center axis of the rock bolt during drilling, but not during retraction of the drill bit. The center axis or middle line CL2 of the reamer part 19 and the axis of the drill steel 11 coincide, but are substantially spaced from the axis CL3 of the hole 22. It should be noted that neither the pilot part nor the reamer part has to be circular in cross-section, so the reference to axes CL1 and CL2 shall be understood as a reference to average middle lines in the respective parts.

The one-piece rock drill bit 16 comprises a body 25 and cemented carbide means, i.e. chisels and/or buttons 17, 18 and 17', 18'. The body of the drill bit is made of steel. The body 25 comprises the substantially conical pilot part 14 and the substantially conical reamer part 19. The pilot part 14 can have a circular cross-section as can be seen in Fig. 2B. The pilot part has a front face carrying a diametrically extending chisel 17 or two diametrically opposed front buttons 17'. The reamer part 19 can have circular cross-section as can be seen in Fig. 2B. The reamer part has a front face carrying three front buttons 18 or four front buttons 18'. The front faces may be convex or substantially planar. The buttons 18, 18' may form a peripheral arch on the reamer part. The buttons 18, 18' may project somewhat outside the periphery of the reamer part in order to machine a hole during drilling which has a somewhat bigger diameter than the steel body.

Chipways or recesses can be provided in areas between adjacent reamer buttons, through which flush medium can pass. The rock drill bit is to be coupled to the drill steel 11 by means of a connection portion, not shown, or to a driver sub of a down-the-hole hammer, not shown, so as to transfer rotational movement in the usual manner. The drill steel 11 includes a channel for conveying a flush medium. A main channel for flush medium is provided inside the drill bit. This main channel communicates at its forward end with a number of branch channels, which exit in the front faces. The flush medium will in practice be water, cement or air. The pilot part makes a pilot hole 22A of less diameter and length in relation to the hole 22. Dimensions of importance are as follows:

RP is the greatest radius of the pilot part 14 as compared to the axis CL3 of the hole. **RR** is the greatest radius of the reamer part 19. **1/2(RP+RR)** is the radius of the reamer part 19 as compared to the axis CL2 of the drill steel 11. **DH** is the hole 22 diameter that equals **2x RR**. The tube 21 thickness is depicted by **E**. **OFF** is the offset between axis CL3 of the hole 22 and axis CL2 of the drill steel 11. **DD** is the diameter of the drill steel 11. **DI** is the minimum diameter in which the drill bit 16 can travel freely. **DB** is the greatest diametrical dimension of the drill bit 16. **OD** is the outer diameter of the rock bolt. The following formulas are applicable:

RR=1/2DH,

RP<OD-RR-2E applicable on rock bolts 21 and 121 or

2RR-E ≤ DI ≤ 2RR-2E applicable on rock bolts 221 and 321 to allow the drill bit 16 to retract through the rock bolt,

DD< RR+RP-2E to allow the drill steel 11 to run eccentrically in the bolt 21.

DB=RP+RR

Example: The following dimensions could be suitable for bolting applications: RR=19 mm, RP=14 mm, OFF=2,5 mm and 10mm<L<60mm.

The operation of the single pass rock bolting apparatus 10 is shown in Figs. 1A – 1G. The drill bit 16 is connected, for example threaded, to the drill steel 11. A drilling machine such as a standard drill jumbo holds the drill steel. The bolt 21 is preferably automatically fed around the drill steel and positioned behind the drill bit 16 in the drilling direction F. In Fig. 1A the pilot part 14 primarily will abut

against the rock such that for a short while it will machine the rock surface during circular interpolation. Then the pilot part 14 will find its correct center and begins to drill centrally while the drill steel 11 simultaneously starts wobbling about the pilot part axis CL1, see Fig. 1B. Then the reamer part 19 gets in contact with the rock surface and begins to ream the hole made by the pilot part 14. After a short while, the bolt 21 reaches the hole and is forced into the hole as shown in Figs. 1C and 1H. Usually the bolt 21 is spaced axially from the drill bit 16. The split bolt 21 can assume the diameter of the hole 22 through compression. The drill bit 16 will continue to drill and ream the hole 22, while the bolt is pushed forwardly by a coupling sleeve 26 of the drilling machine, see Fig. 1D, until feed of the different parts is stopped. The depth of the hole 22 is substantially determined by the length of the bolt 21, i.e. when a washer 23 positioned at the trailing end of the bolt reaches the rock face or entrance of the hole further feed will be stopped, see Fig. 1E. There is a rock bolt pusher on the drilling machine. The bolt pusher is a coupling sleeve 26 or a dolly tool 27, see Fig. 1L, which is driven by the drill steel. The dolly tool 27 rotates together with the drill steel and the bolt during insertion. It can torque an expansion shell rock bolt when fully inserted. The dolly tool can also slide along the drill steel to allow an easier installation of mechanical shell bolts and grouted bolts. Fig. 1E shows the rock bolt fully inserted, with the drill steel and drill bit fully inserted and the pusher pushing the plate to the rock face. The washer is a loose conventional plate having a central hole that cooperates with a bulge 24 at the trailing end of the bolt. Then the drill bit is retracted from the pilot hole 22A, see Figs. 1F and 1K. It is preferable that the axial space between the bolt and the drill bit is greater than the depth of the pilot hole 22A such that the leading end of the bolt does not interfere with the retraction of the drill bit. The drill bit and the drill steel can be completely retracted and can be reused for repeated drilling operations. Stated another way, the method of single pass rock bolting comprises the following steps.

- providing a single pass drilling apparatus 10 comprising:

an elongated drill steel 11 having a leading 12 and a trailing 13 end with reference to a drilling direction F, said leading end 12 having a connection

portion 15, a one-piece drill bit 16 having rock machining means 17, 18 or 17', 18', said drill bit being connectable to the drill steel 11,

- enclosing the drill steel 11 at least partially with a rock bolt 21, said drill bit 16 and said rock bolt 21 being designed to allow the drill bit 16 to pass the rock bolt 21 during retraction of the drill bit,
- drilling a hole 22 in a rock while pushing the rock bolt into said hole,
-retracting said drill steel 11 and said drill bit 16 through the rock bolt 21.

The machine driving the apparatus 10 can be a top hammer drilling machine, a rotary machine or a down-the-hole equipment. To avoid deflection, wear and hole diameter reduction due to radial forces from the reamer on the pilot, the top of the pilot could be shaped with an angle diametrically opposite to the reamer part so as to counteract said radial forces. Said forces opposed to the reamer part will help in keeping the reamer part working at its radially outermost portion, and it will also allow wear on the pilot part on the reamer side but not too much wear on its side facing away from the reamer part. The side of the pilot part facing away from the reamer part can be provided with a wear pad. This wear of the pilot part on the reamer side would also be advantageous for maintaining the hole diameter and partly compensating for the peripheral wear of the reamer part. This geometry will provide a self-grinding drill bit.

Figs. 3A and 3B show an alternative embodiment of a drilling apparatus for single pass bolting in similar views as Figs. 1H and 1K. This embodiment differs from the one previously disclosed in that the bolt 121 has a different design. The rock bolt 121 is manufactured from a steel tube that has no longitudinal slot. The rock bolt 121 has a smaller diameter than the drilled hole. When the hole has been drilled as discussed above the drill bit and the drill steel is retracted, see Fig. 3B, while the bolt 121 remains in the hole. The greatest diametrical dimension of the drill bit 16 is smaller than the smallest diametrical dimension DI of the rock bolt 121. The bolt remains in the hole thanks to an external system linked to the drilling device, due to a loose parachute, or due to an integrated parachute on the rock bolt itself.

Then grout or resin is filled internally or externally of the bolt and the filling is allowed to cure or set. A washer is preferably used to cover the entrance of the hole as discussed above.

Figs. 4A and 4B show an alternative embodiment of a drilling apparatus for single pass bolting in similar views as Figs. 1H and 1K. This embodiment differs from the one previously disclosed in that the bolt 221 has a different design. The rock bolt 221 is manufactured from a steel tube that has been deformed to have a deep depression so that it assumes a substantially reduced diameter, i.e. the dimension is reduced to substantially the half of a cylindrical tube. The fluid expansible tube-formed rock bolt 221 has an internal elongated pressure fluid-receiving chamber that is closed at both of its ends but has a fluid inlet. A sleeve is pressed onto the outer end thereof which is sealed through welding or mechanically closed. The bolt is designed as a general U-shape such that the drill bit 16 can pass it. In the radial cross-section in Fig. 4B the ends 221A and 221B are substantially diametrically opposite each other, i.e. the bolt is substantially semi-circular. The rock bolt 221 is adapted at least partially to enclose the drill steel 11. The greatest diametrical dimension DB of the drill bit 16 is smaller than the smallest space or diametrical dimension between the rock bolt and the hole 22.

The drilling operation is performed as discussed above. When the rock bolt has been automatically inserted in a borehole and the drill bit 16 and the drill steel have been retracted as explained above high pressure liquid is conveyed through passages to a hole which leads through the sleeve to an interior chamber of the tube so that the tube expands through plastic deformation, thereby anchoring the rock bolt in the borehole. The rock bolt is then relieved of pressure and becomes anchored. The principal function of pressurizing the fluid chamber is more closely described in US-A-4,423,986. A washer is preferably used to cover the entrance of the hole as discussed above.

Figs. 5A and 5B show an alternative embodiment of a drilling apparatus for single pass bolting in similar views as Figs. 1H and 1K. This embodiment differs from the one previously disclosed in that the bolt 221 has a different design. The rock cable bolt 321 is manufactured from multistrand steel cable. The drill bit 16

drills and reams in one drilling operation. When the hole has been drilled as discussed above the drill bit and the drill steel is retracted, see Fig. 3B, while the bolt 321 remains in the hole. The greatest dimension DI in connection with the cable bolt 321 is the space available between the cable when pressed onto the hole wall and the diametrically opposite hole wall.

Then grout or resin is filled internally or externally of the bolt and the filling is allowed to cure or set. Cable bolting is an established technique used extensively for reinforcement of the rock mass adjacent to surface and underground rock excavations. Cable bolts are long, fully grouted, and untensioned reinforcing elements. The objective of cable bolting is to improve the shear and tensile strength of the rock mass.

The single pass drilling apparatus according to the various embodiments of the present invention comprises a rock bolt adapted to at least partially enclose the drill steel during drilling and the greatest diametrical dimension of the drill bit is smaller than the smallest diametrical dimension of the rock bolt.

Advantages for use of a self-drilling bolt are:

- Drilling and setting are simultaneously performed.
- Fast and easy installation reduces bolting costs:
- Qualified for difficult geological conditions, specially with unstable drill holes.
- Rock consolidation when grouting.
- Choice of bolts pending on the ground conditions.
- Drilling and setting with standard drill jumbos.
- No special equipment needed.
- The drill bit can be used for drilling several holes.
- The drill bit needs no keying into position before retraction can be started.

The invention described herein is susceptible to variations, modifications and/or additions other than those specifically described and it is to be understood that the invention includes all such variations, modifications and/or additions which fall within the scope of the claims. There is no limitation to rotary percussive top hammers. The concept is valid with pure rotary drilling or DTH drifters too. The number of cemented carbide buttons in pilot and reamer parts

can be varied depending on how great the diameter of the drill bit is. The reamer part may be provided with a hard sleeve or insert substantially flush with its jacket surface that aims to maintain the reamer part diameter and to improve the hole wall quality. It is also understood that the drill steel and the rock bolt can be extended with one or more components when deeper holes are to be drilled.

Claims:

1. A single pass drilling apparatus comprising:
an elongated drill steel (11) having a leading (12) and a trailing end (13) with reference to a drilling direction (F), said leading end (12) having a connection portion,
a one-piece drill bit (16) having rock machining means (17,18;17'18'), said drill bit being connectable to the drill steel,
c h a r a c t e r i z e d i n that the single pass drilling apparatus (10) further comprises a rock bolt (21;121,221;321) adapted to at least partially enclose the drill steel (11) and in that the drill bit (16) and the rock bolt (21;121,221;321) are designed to allow the drill bit (16) to pass the rock bolt (21;121,221;321) during retraction of the drill bit.

2. The single pass drilling apparatus according to claim 1, c h a r a c t e r i z e d i n that the greatest diametrical dimension (DB) of the drill bit (16) is smaller than the smallest diametrical dimension (DI) of the rock bolt and in that the one-piece drill bit (16) comprises a pilot part (14) and a reamer part (19) having spaced middle lines (CL1 and CL2, respectively).

3. The single pass drilling apparatus according to claim 2, c h a r a c t e r i z e d i n that the middle line (CL1) of the pilot part (14) substantially coincides with the center axis of the rock bolt during drilling.

4. The single pass drilling apparatus according to claim 2, c h a r a c t e r i z e d i n that the middle line (CL2) of the reamer part (19) substantially coincides with the rotational axis of the leading end (12) of the drill steel (11).

5. Use of a drill bit in a single pass drilling apparatus, said single pass drilling apparatus comprising:

an elongated drill steel (11) having a leading (12) and a trailing end (13) with reference to a drilling direction (F), said leading end (12) having a connection portion,
a one-piece drill bit (16) having rock machining means (17,18;17',18'), said drill bit being connectable to the drill steel,
c h a r a c t e r i z e d i n that the single pass drilling apparatus (10) further comprises a rock bolt (21;121,221;321) adapted to at least partially enclose the drill steel (11) and in that the drill bit (16) and the rock bolt (21;121,221;321) are designed to allow the drill bit (16) to pass the rock bolt (21;121,221;321) during retraction of the drill bit.

6. The single pass drilling apparatus according to claim 5, c h a r a c t e r i z e d i n that the greatest diametrical dimension (DB) of the drill bit (16) is smaller than the smallest diametrical dimension (DI) of the rock bolt and in that the one-piece drill bit (16) comprises a pilot part (14) and a reamer part (19) having spaced middle lines (CL1 and CL2, respectively).

7. Method of single pass rock bolting comprising the following steps:
- providing a single pass drilling apparatus (10) comprising:
an elongated drill steel (11) having a leading (12) and a trailing end (13) with reference to a drilling direction (F), said leading end (12) having a connection portion,
a one-piece drill bit (16) having rock machining means (17,18;17'18'), said drill bit being connectable to the drill steel,
- enclosing the drill steel at least partially with a rock bolt (21;121,221;321), said drill bit (16) and said rock bolt (21;121,221;321) being designed to allow the drill bit (16) to pass the rock bolt (21;121,221;321) during retraction of the drill bit,
- drilling a hole in a rock while pushing the rock bolt into said hole,
-retracting said drill steel and said drill bit through the rock bolt.

8. The method according to claim 7, wherein the method comprises the further step of providing the drill bit (16) as a one-piece drill bit comprising a pilot part

(14) and a reamer part (19) having spaced middle lines (CL1 and CL2, respectively).

9. A rock bolt for a single pass drilling apparatus as defined in claim 1, said rock bolt (221) having a partly tube shaped body having a leading end and a trailing end, said trailing end having a washer and a washer stop means, said rock bolt (221) being fluid expansible,
characterized in that the rock bolt (221) is substantially semi-circular and designed as a general U-shape to allow passage of a drill bit.

10. The rock bolt according to claim 9, characterized in that ends (221A,221B) in a radial cross-section of the rock bolt are substantially diametrically opposite to each other.

Abstract

The present invention relates to a single pass drilling apparatus, a rock bolt, use of a drill bit and a method for single pass rock bolting for reinforcement and stabilization of excavations. The single pass drilling apparatus comprises an elongated drill steel (11) having a leading (12) and a trailing end (13) with reference to a drilling direction (F). The leading end (12) has a connection portion. A one-piece drill bit (16) is utilized having rock machining means (17,18;17'18'). The drill bit is connectable to the drill steel. The single pass drilling apparatus (10) further comprises a rock bolt (21;121,221;321) adapted to at least partially enclose the drill steel (11). The greatest diametrical dimension (DB) of the drill bit (16) is smaller than the smallest diametrical dimension (DI) of the rock bolt.

(Fig. 2A)

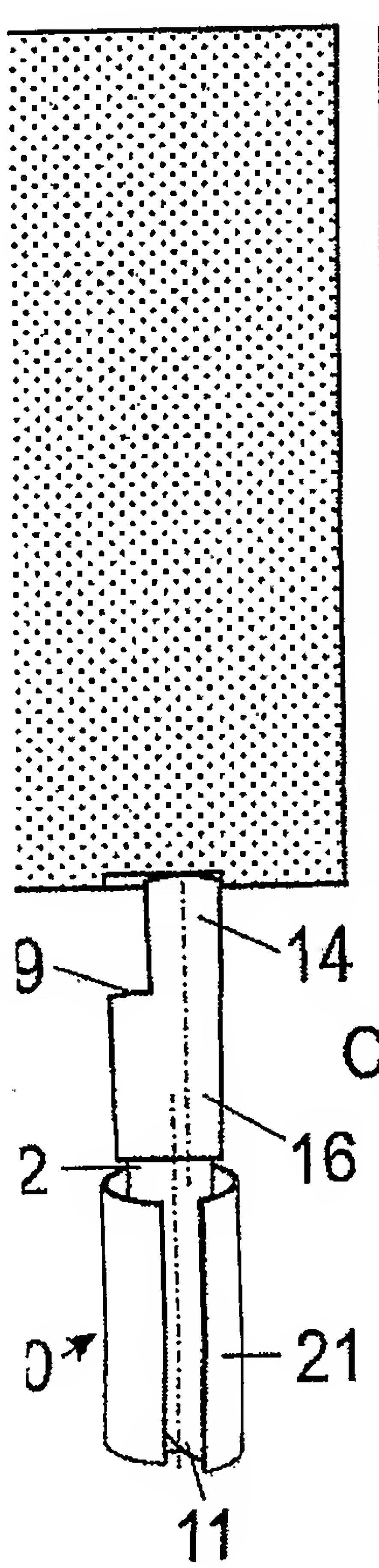

FIG. 1A

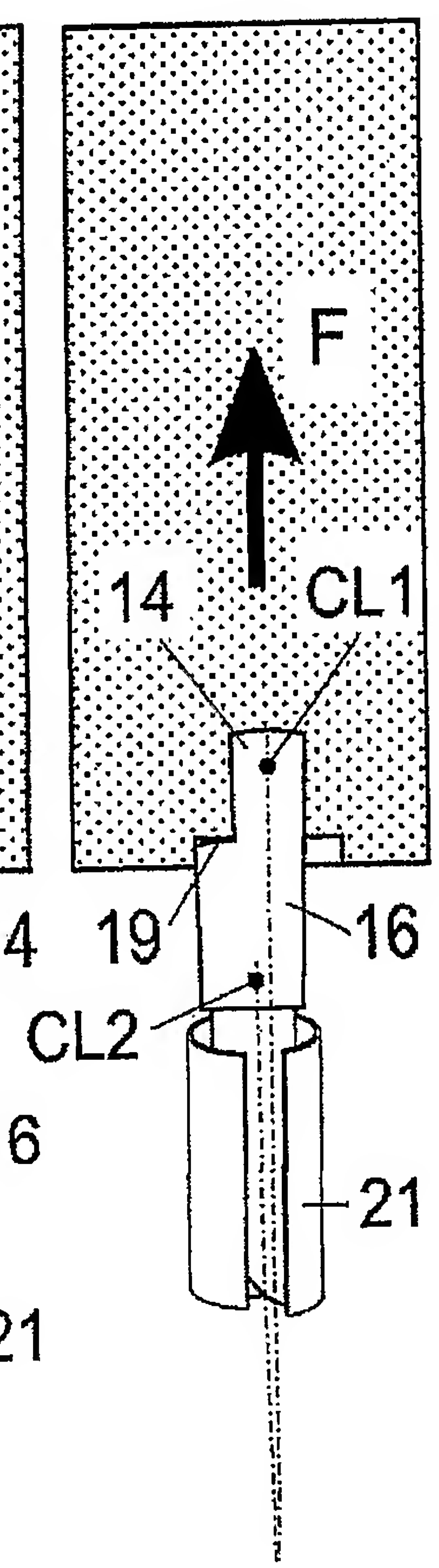

FIG. 1B

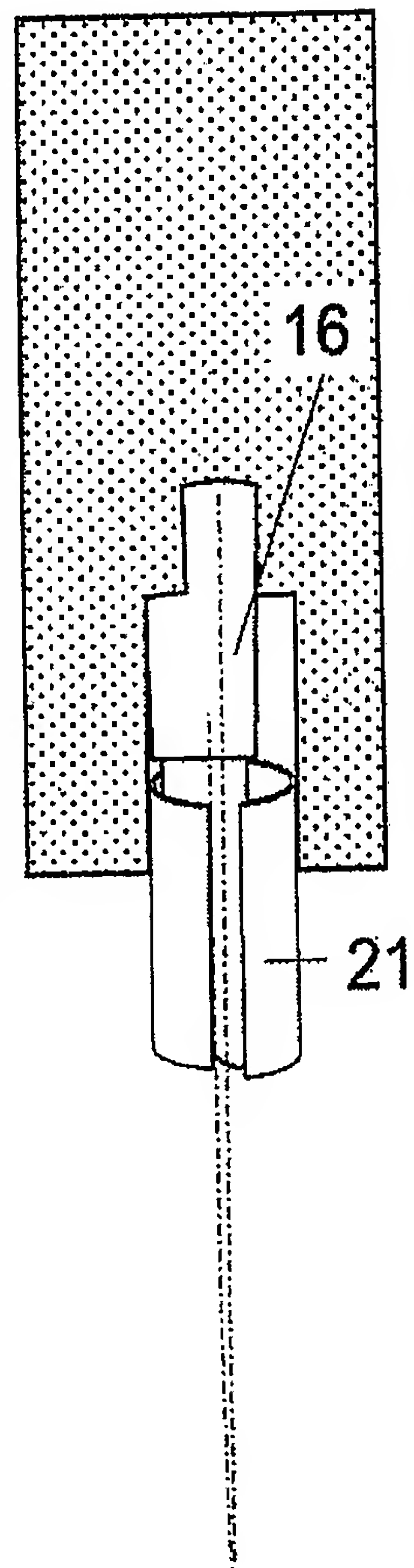

FIG. 1C

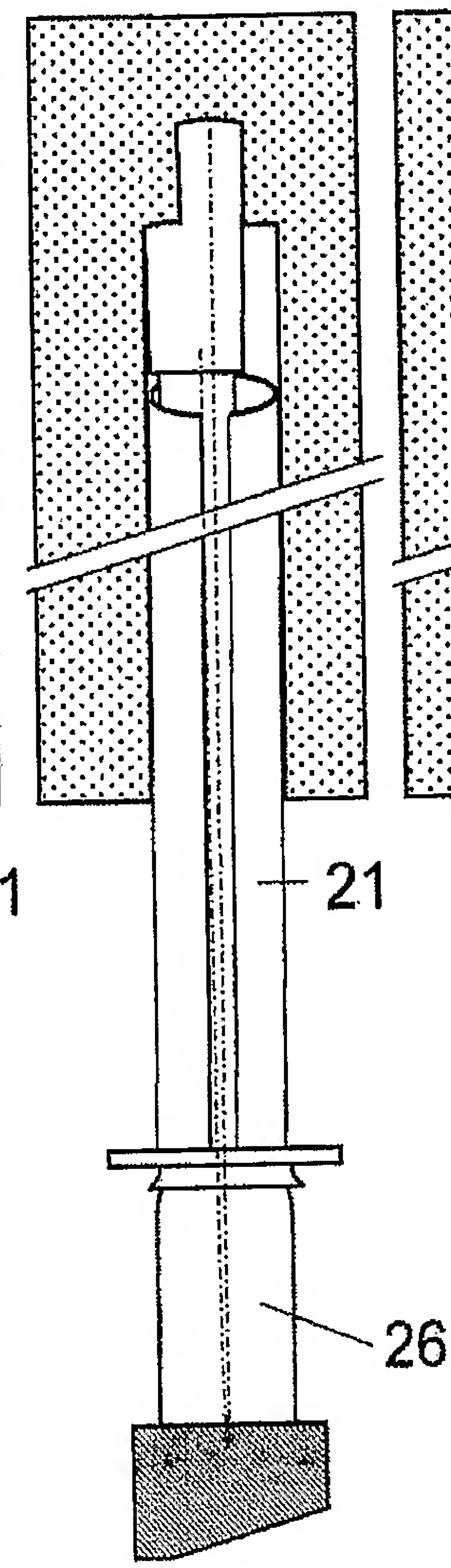

FIG. 1D

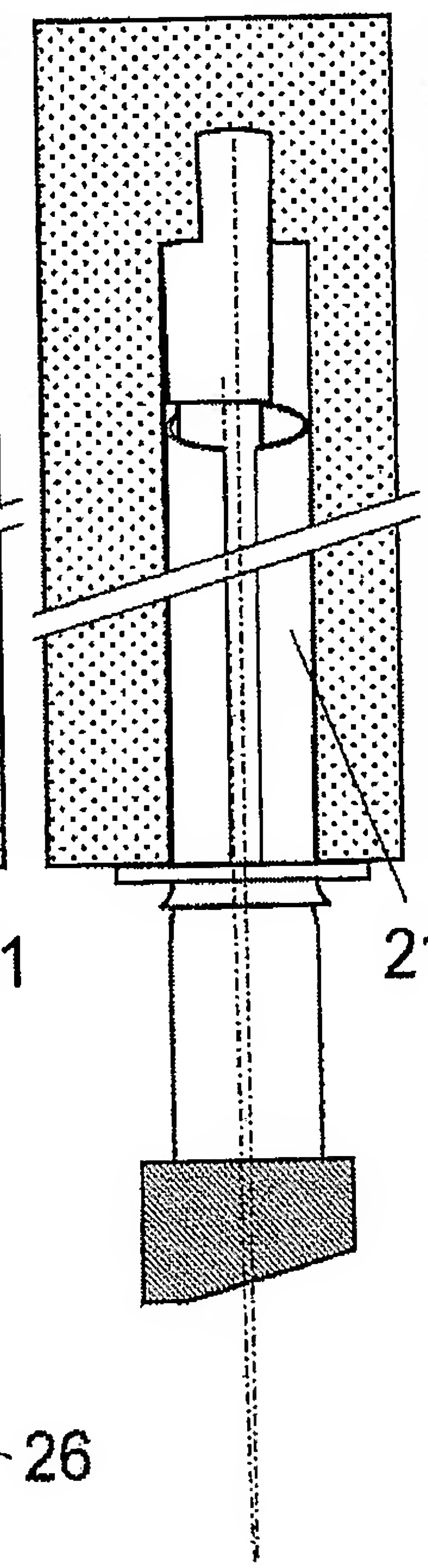

FIG. 1E

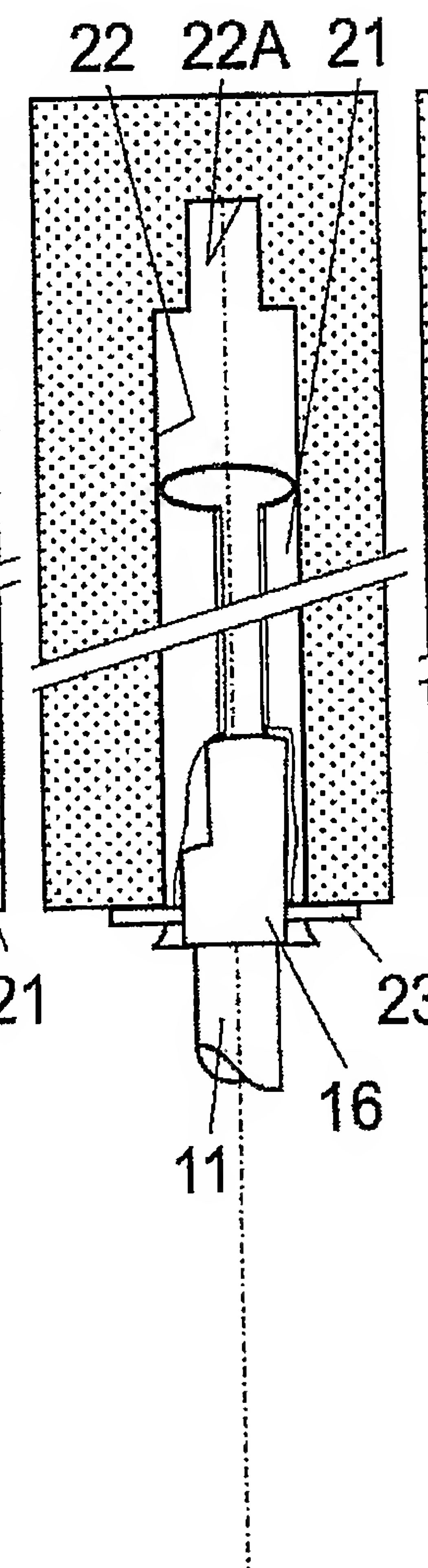

FIG. 1F

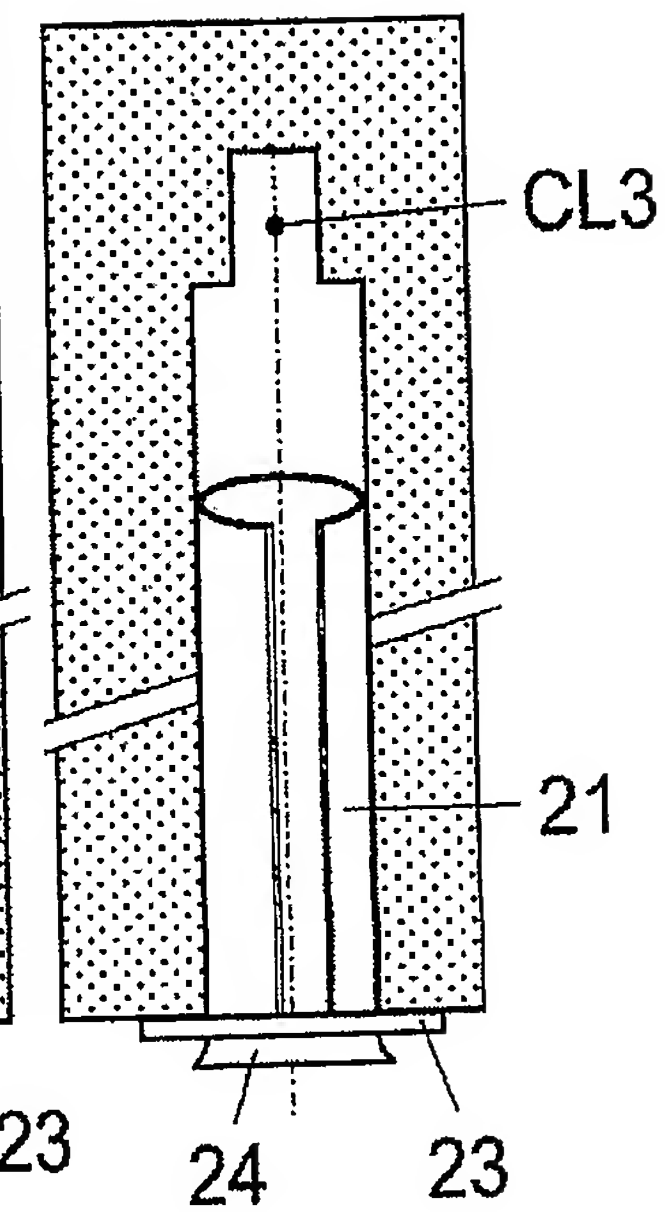

FIG. 1G

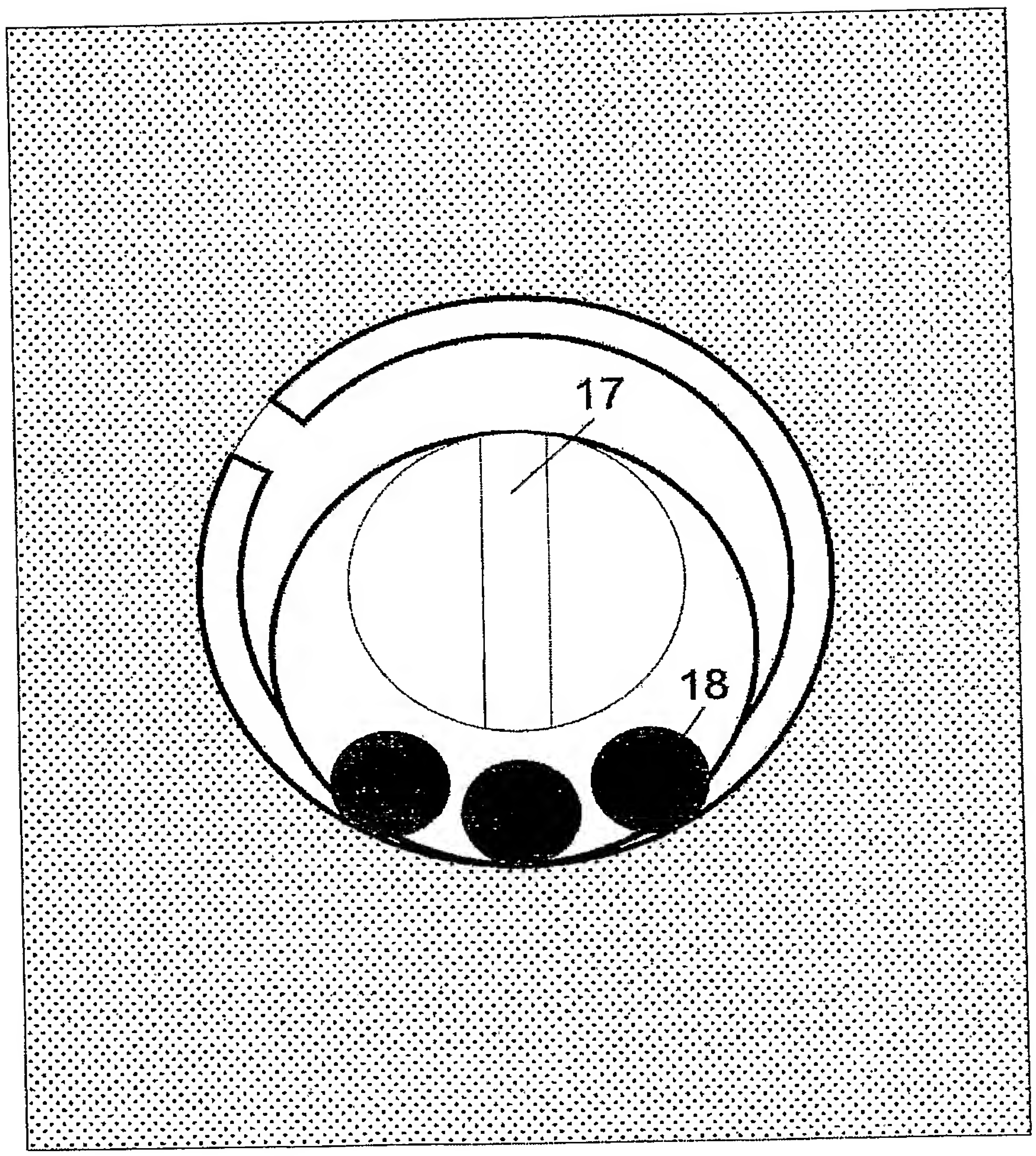

FIG. 1H

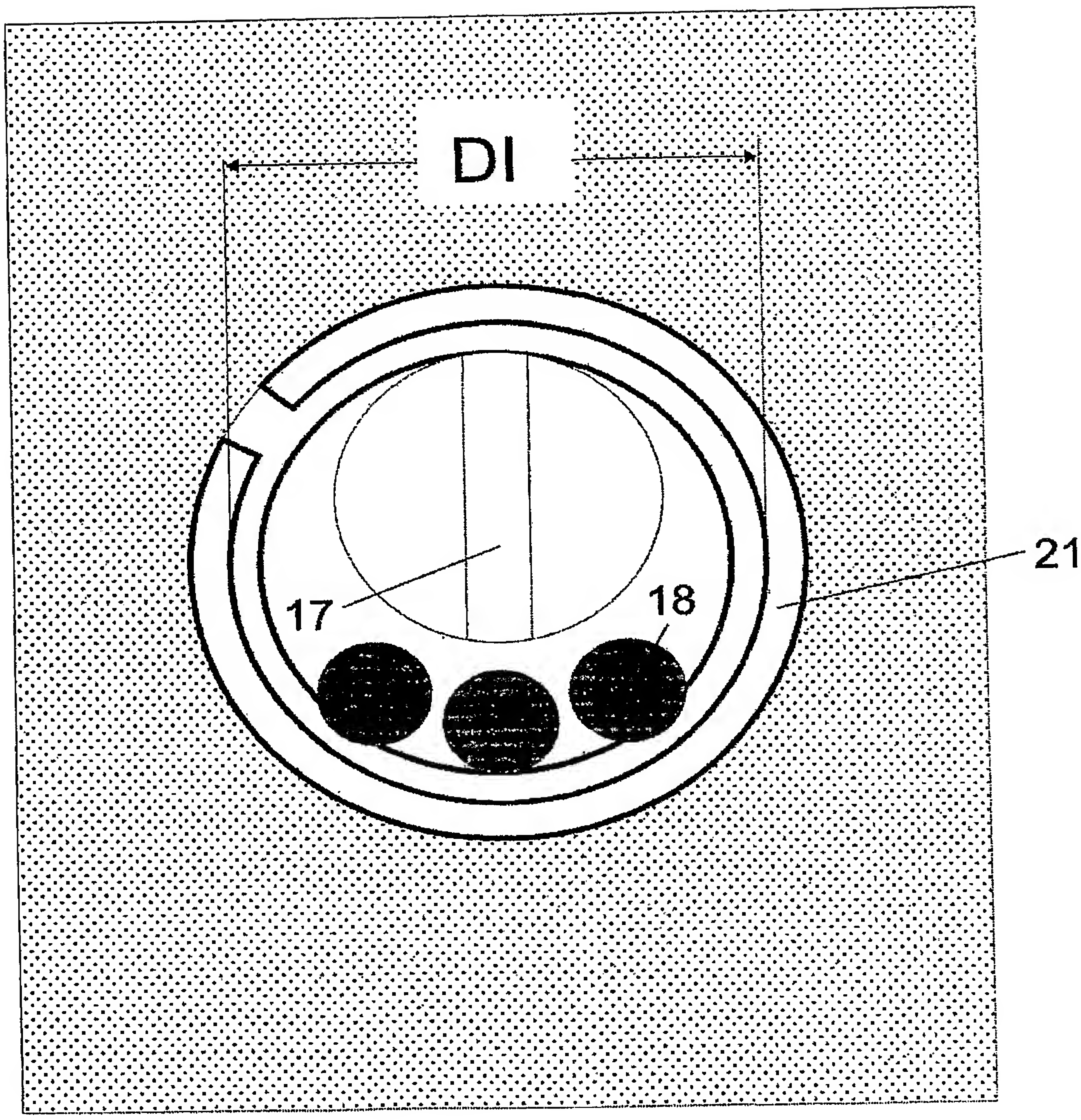

FIG. 1K

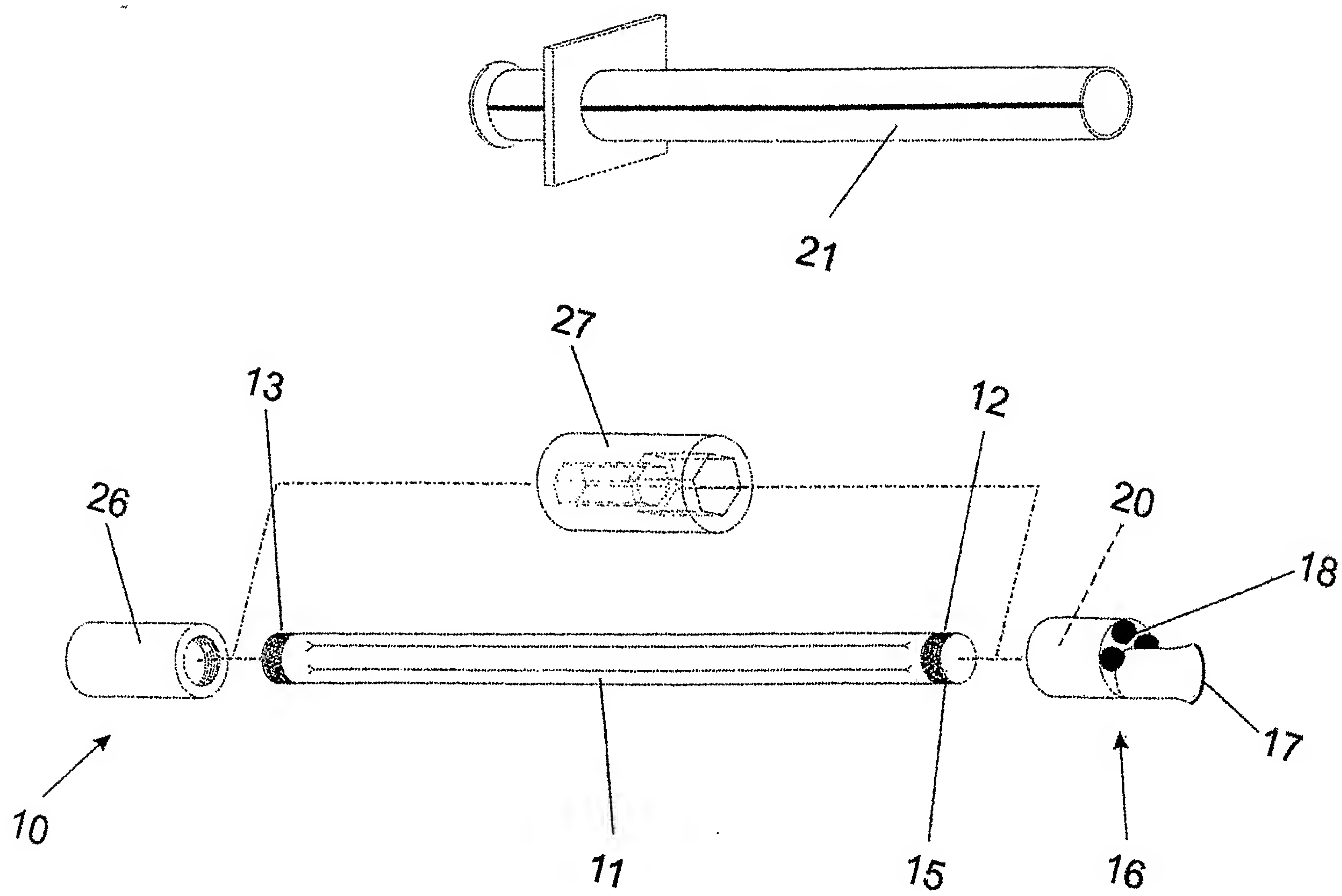

FIG. 1L

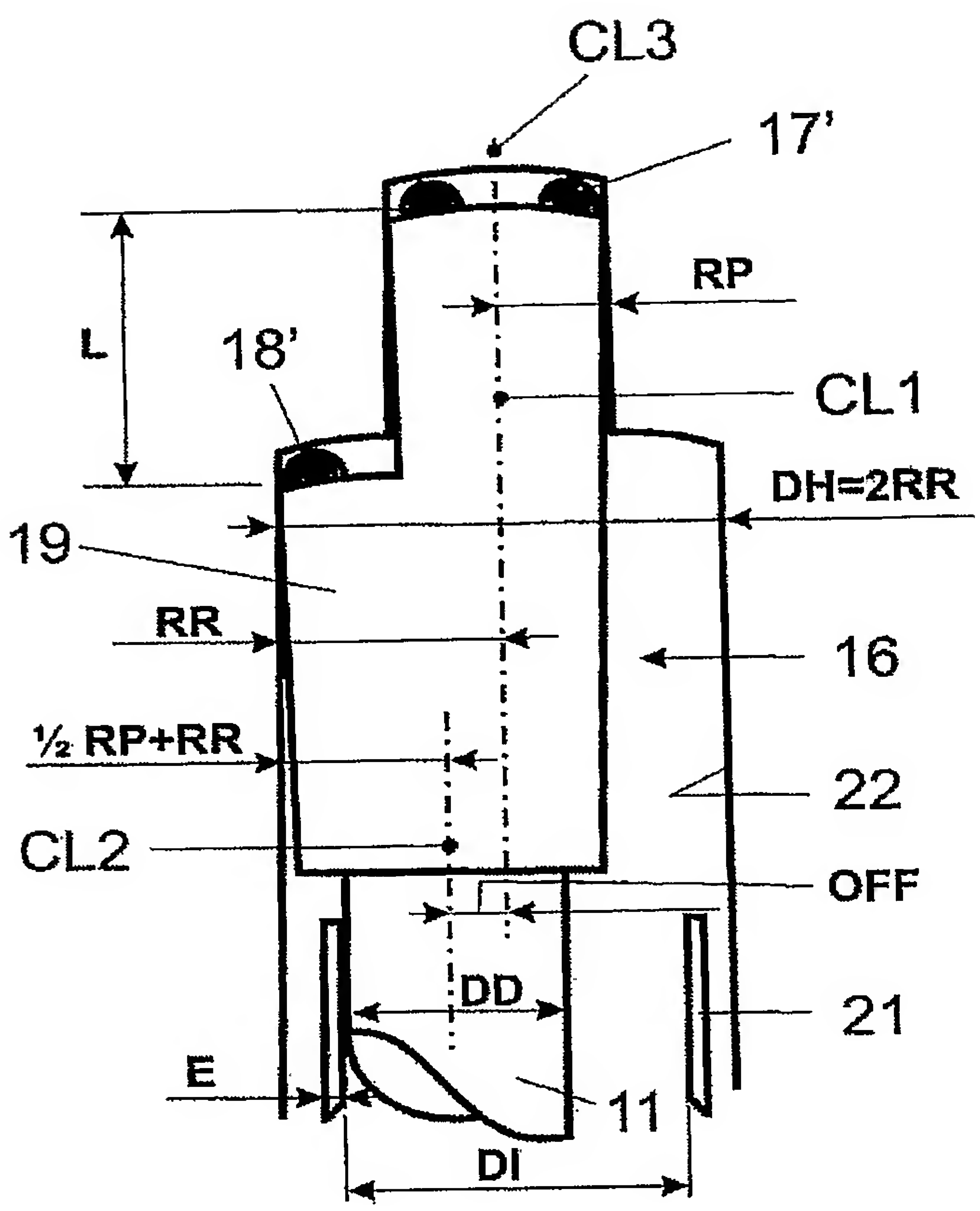
CL3
17'
RP
L
18'
CL1
DH=2RR
19
RR
16
½ RP+RR
22
CL2
OFF
DD
21
E
11
DI

FIG. 2A

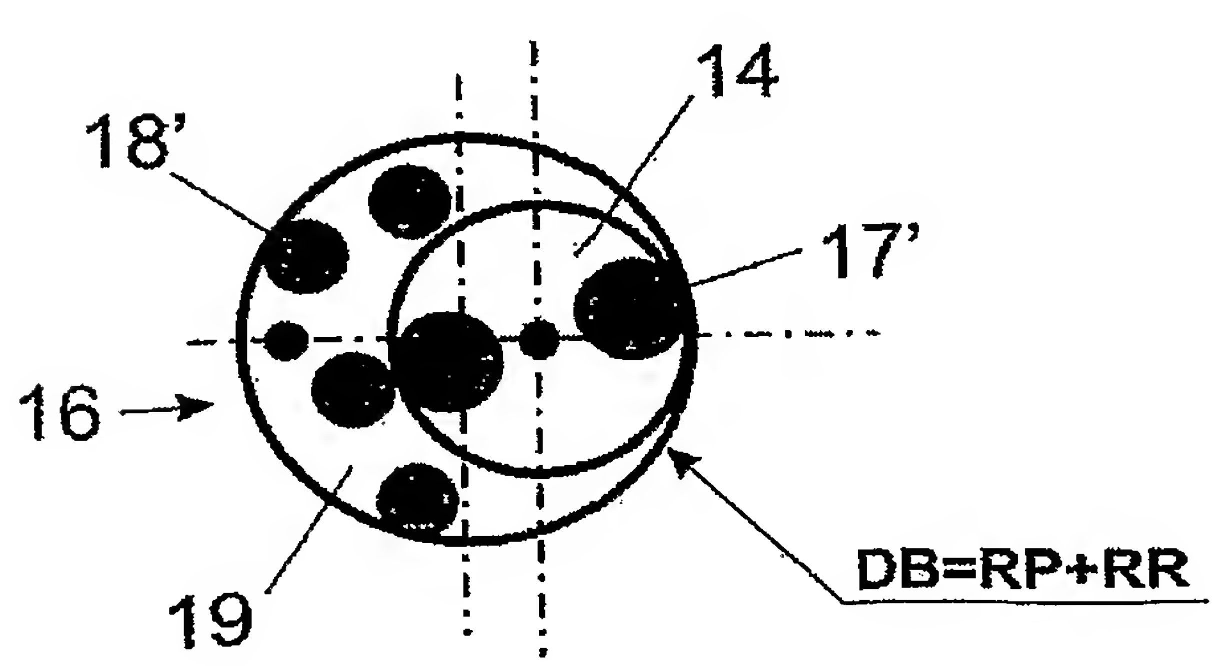
14
18'
17'
16
19
DB=RP+RR

FIG. 2B

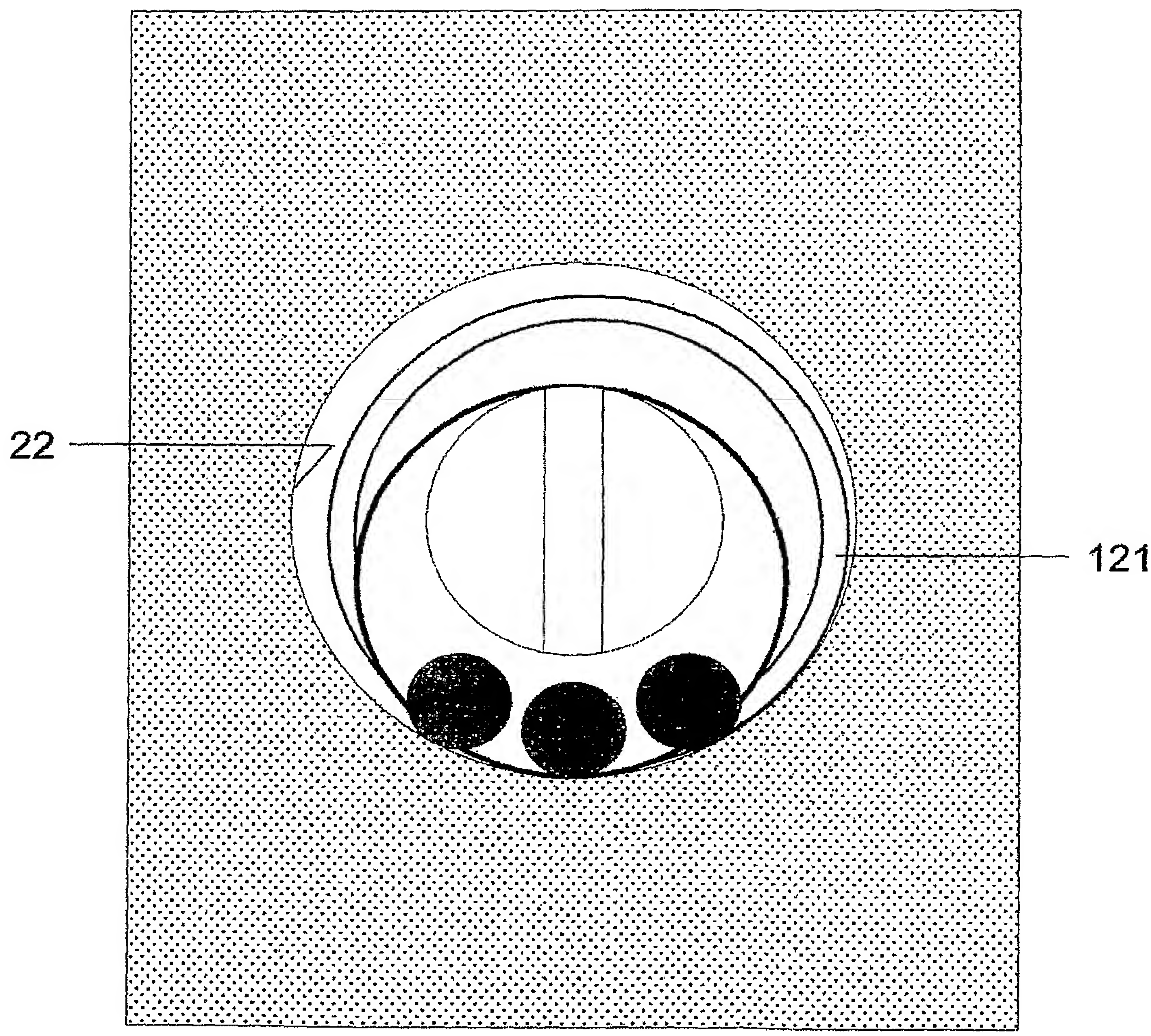

FIG. 3A

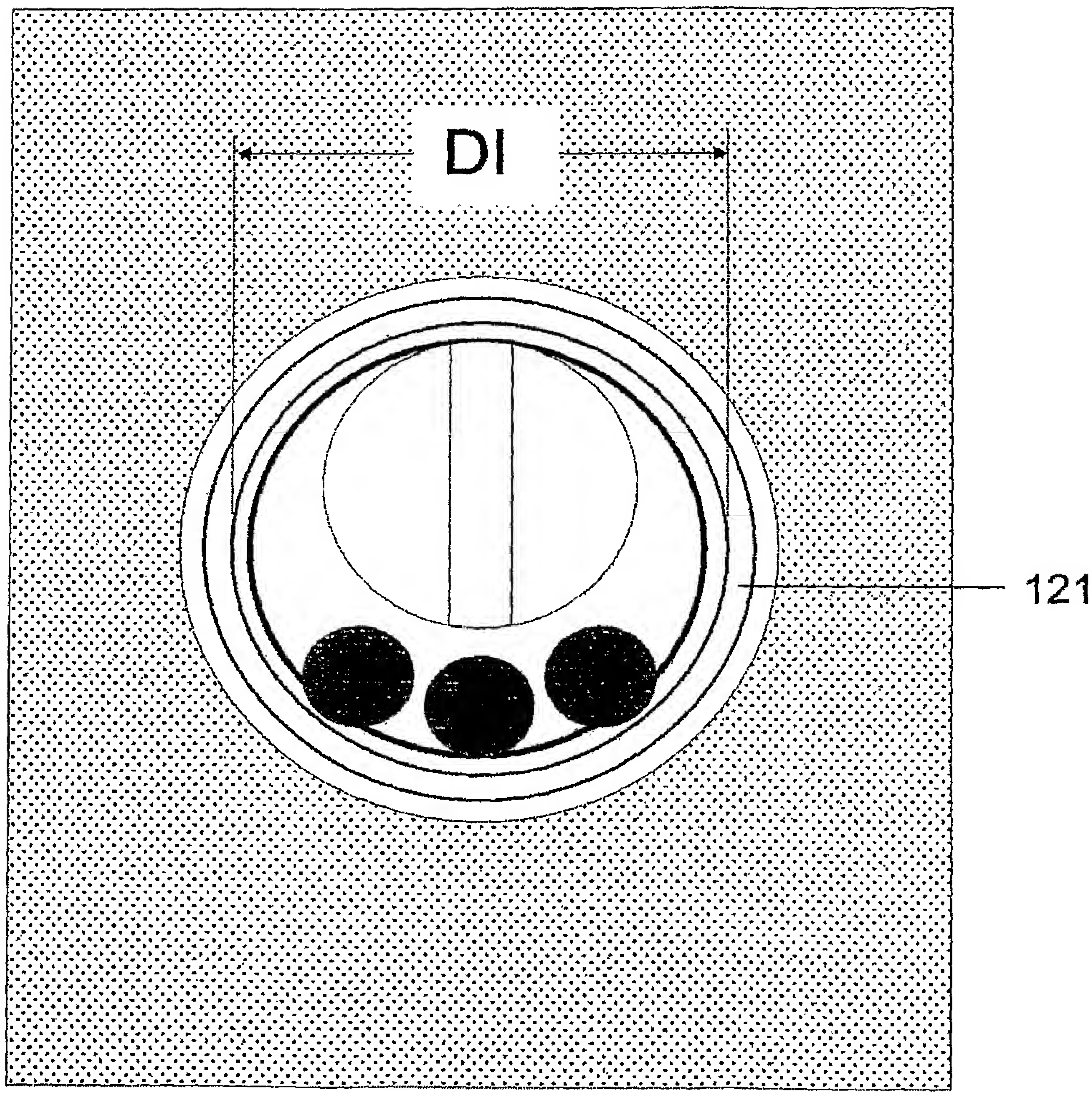

FIG. 3B

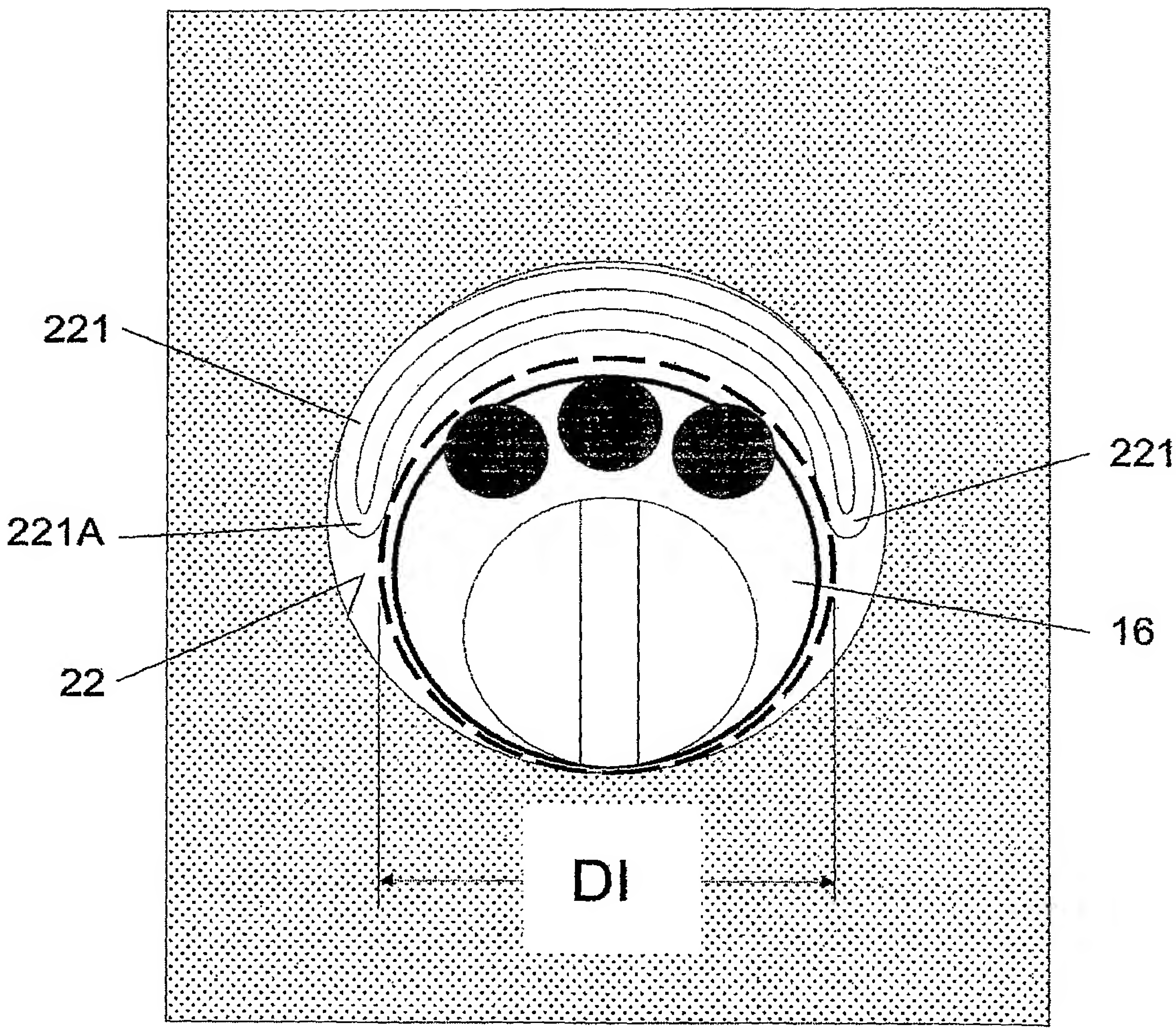

FIG. 4B

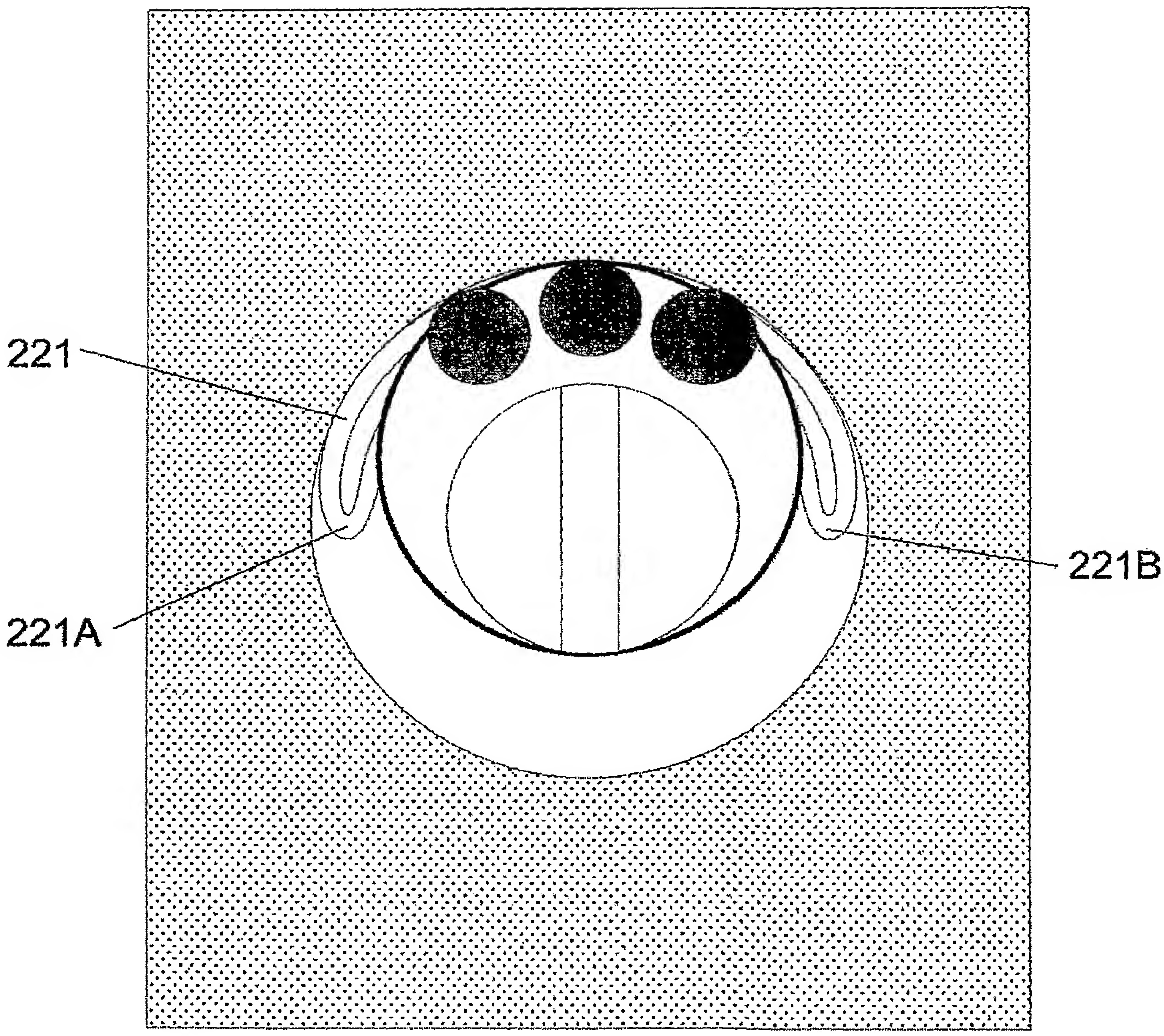

FIG. 4A

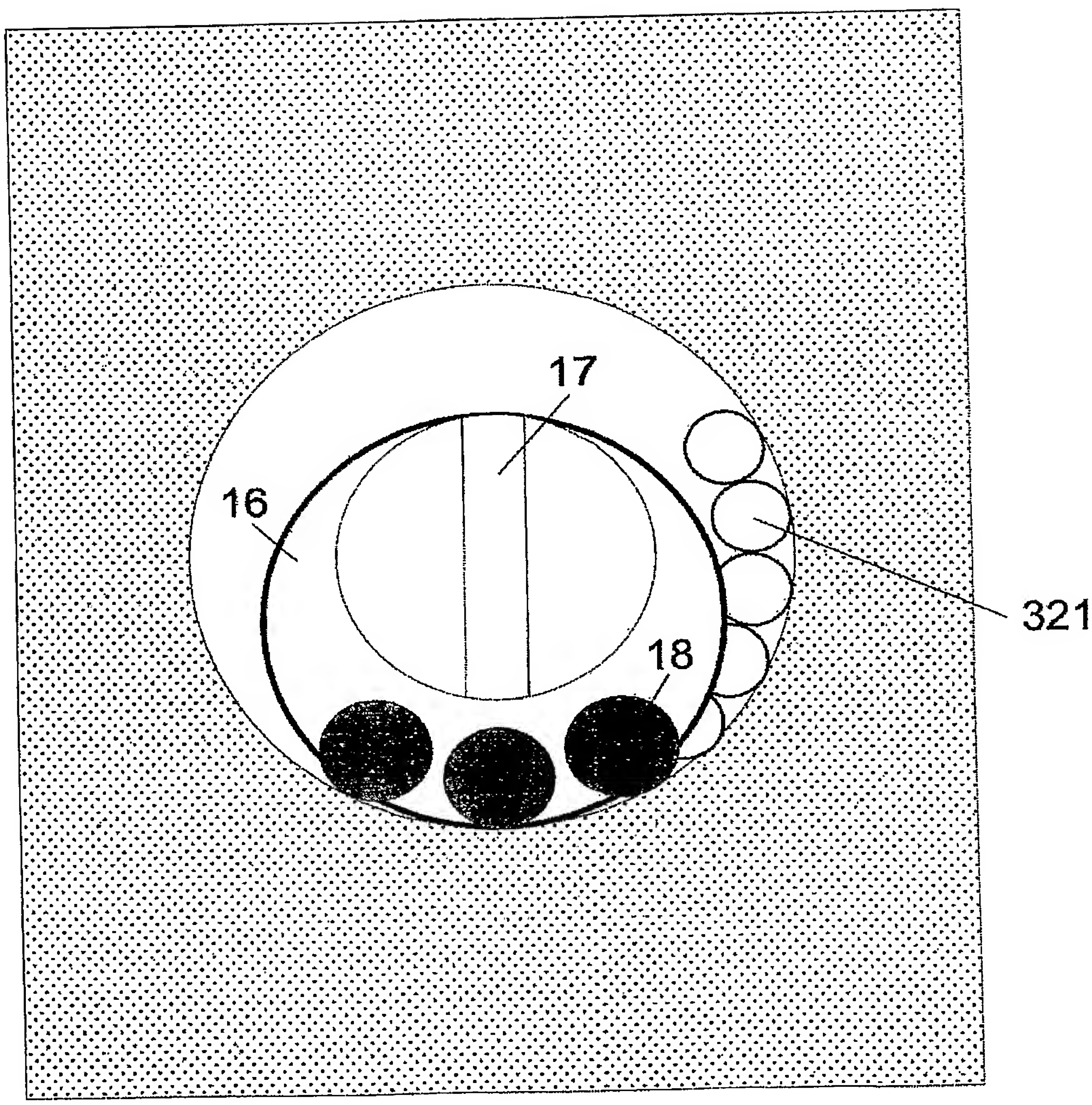

FIG. 5A

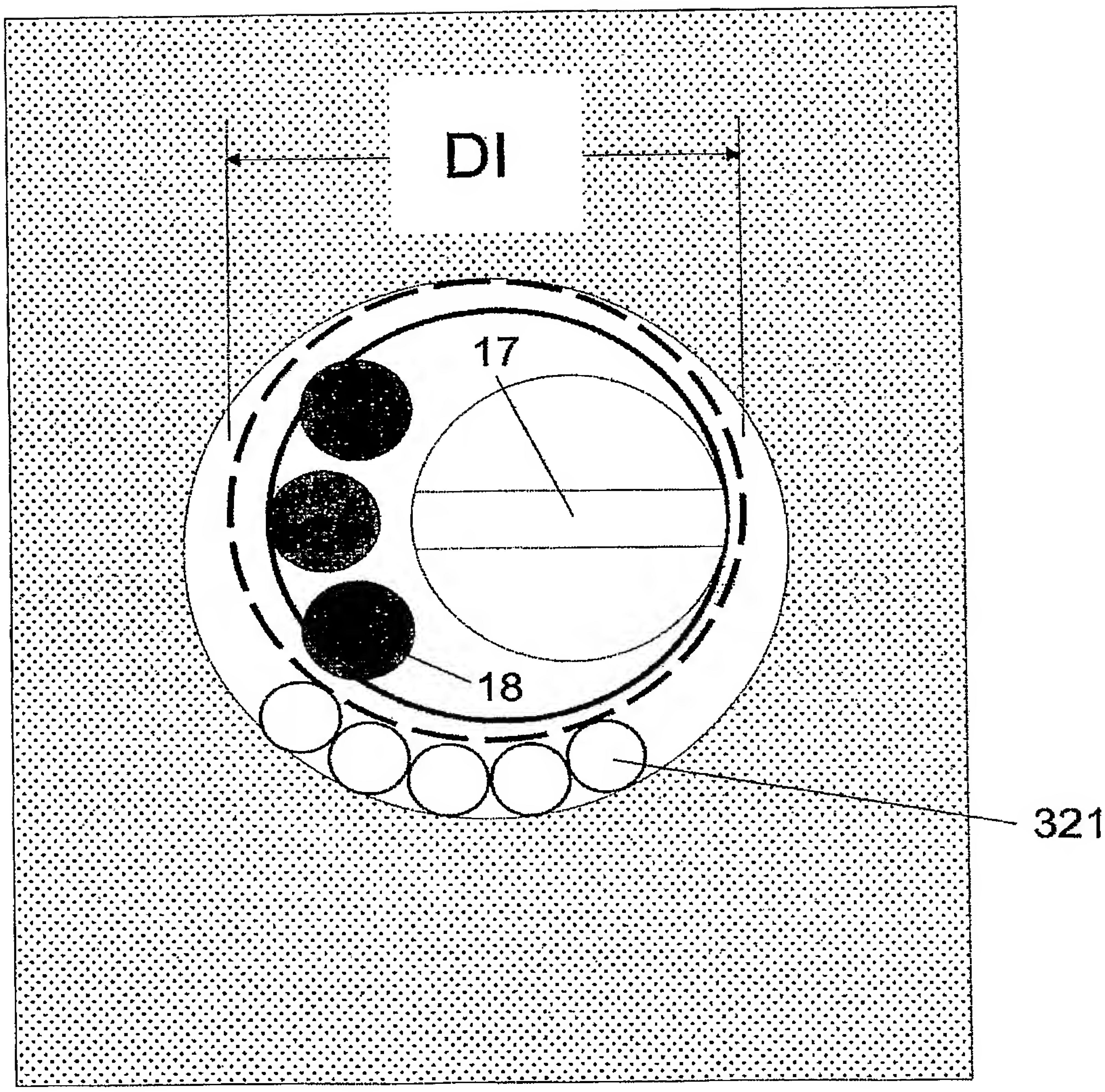

FIG. 5B